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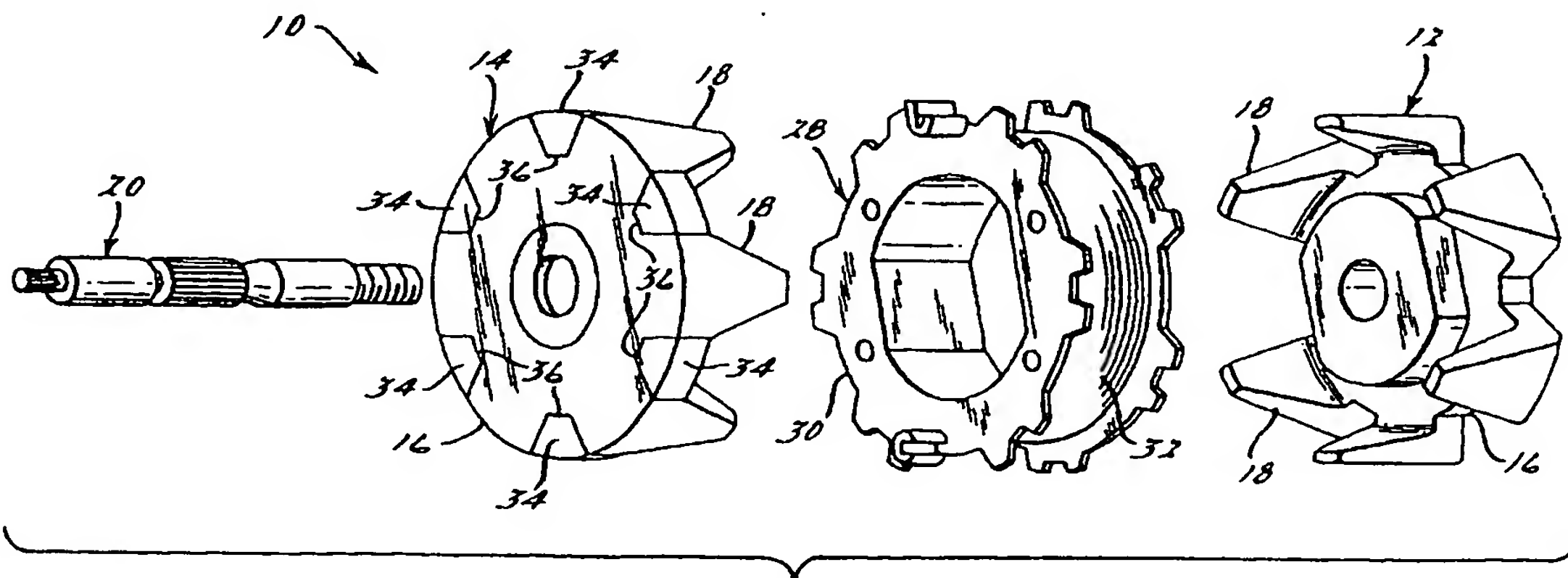
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**(54) Rotating electrical machine with permanent magnet inserts**

(57) In one embodiment of the present invention, a rotor (10) for an electrical machine comprises a first pole piece (12) and a second pole piece (14) together defining an axis of rotation of the rotor, each pole piece (12,14) comprising a generally disc-shaped body (16) having a circumference. Each pole piece further has a

plurality of angularly-spaced pole fingers (18) extending axially from the circumference of the body of the pole piece. The rotor additionally includes a plurality of permanent magnets (34), each permanent magnet affixed to a body (16) of a pole piece between two pole fingers of the pole piece.



**FIG. 1.**



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# EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 96, no. 3, 29 March 1996 & JP 07 312854 A (HITACHI), 28 November 1995, * abstract *	1-5	H02K1/24 H02K1/27
X	& JP 07 312 854 A (HITACHI)	1-5	
Y	* figures 11,12 *	8-10	
Y	US 4 445 062 A (GLASER) * column 4, line 29 - line 47; figures *	8-10	
A	US 5 552 651 A (RADOMSKI) * column 3, line 36 - line 45; figures 4,5 * -----	1,2,5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H02K
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 19 January 1998	Examiner Kempen, P
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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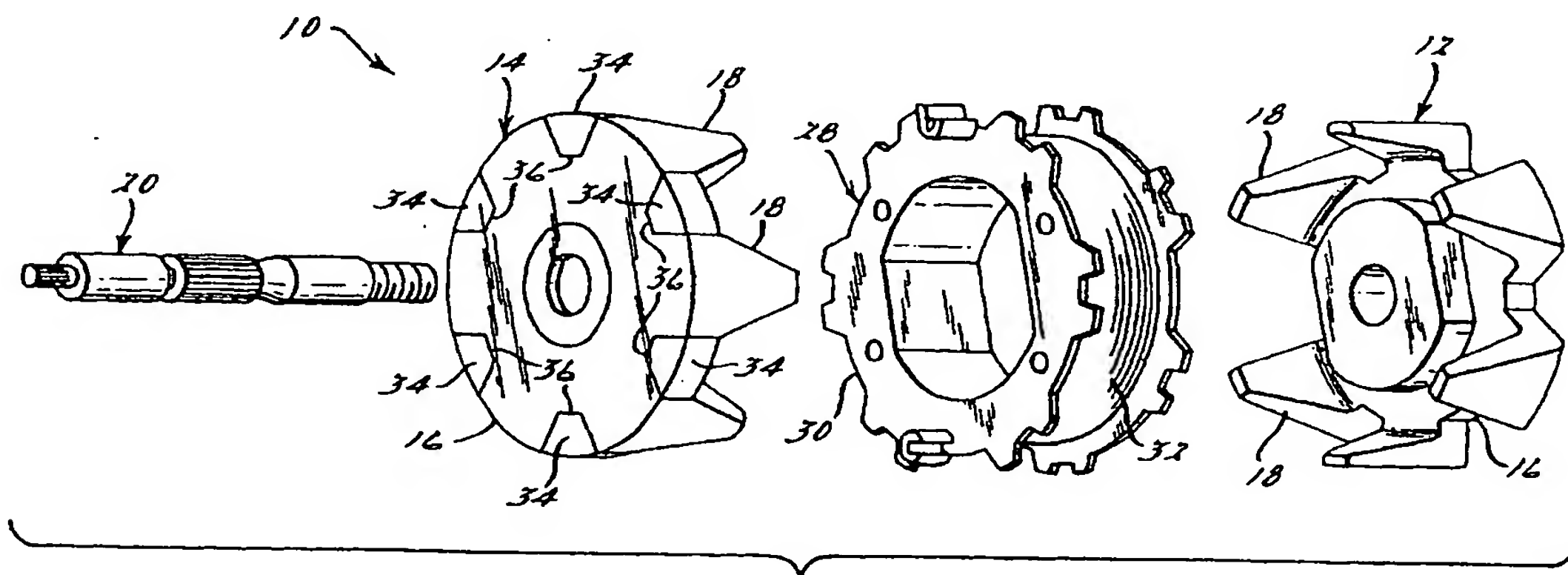
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### (54) Rotating electrical machine with permanent magnet inserts

(57) In one embodiment of the present invention, a rotor (10) for an electrical machine comprises a first pole piece (12) and a second pole piece (14) together defining an axis of rotation of the rotor, each pole piece (12,14) comprising a generally disc-shaped body (16) having a circumference. Each pole piece further has a

plurality of angularly-spaced pole fingers (18) extending axially from the circumference of the body of the pole piece. The rotor additionally includes a plurality of permanent magnets (34), each permanent magnet affixed to a body (16) of a pole piece between two pole fingers of the pole piece.



**FIG. 1.**

## D scripti n

The present invention relates to electrical machines.

Lundell or "claw pole" alternators are well-known, for example as electrical generators for motor vehicles. Such machines have very attractive attributes such as low cost and a mature design. However, with the ever-increasing electrical accessory content on motor vehicles, the need for greater electrical generating capacity is needed.

Certainly, one option is to use larger and larger Lundell alternators. However, the generally reducing size of vehicles makes packaging larger and larger alternators difficult. Thus, an alternator with a higher power density (that is, more power output per unit volume of the machine) than a conventional Lundell alternator can prove advantageous.

However, as was mentioned above, Lundell alternators themselves have considerable advantages. Thus, an electrical machine design which preserves the advantages of a conventional Lundell machine while increasing its power density will provide advantages over alternative designs. Increasing the power density of the Lundell machine without abandoning the basic Lundell design can certainly help preserve the cost advantages of a Lundell machine. Also, using a modification of the basic Lundell design can allow the wealth of design and manufacturing expertise which has been developed in connection with Lundell machines to continue to be used.

Therefore, an electrical machine design which can provide higher power density within the general parameters of Lundell machine design can provide advantages over the prior art.

The present invention provides a rotor for an electrical machine. The rotor comprises a first pole piece and a second pole piece together defining an axis of rotation of the rotor, each pole piece comprising a generally disc-shaped body having a circumference, each pole piece further having a plurality of angularly-spaced pole fingers extending axially from the circumference of the body of the pole piece. The rotor additionally includes a plurality of permanent magnets, each permanent magnet affixed to a body of a pole piece between two pole fingers of the pole piece.

The present invention further provides a method for manufacturing a rotor for an electrical machine, the rotor comprising a first pole piece and a second pole piece together defining an axis of rotation of the rotor, each pole piece comprising a generally disc-shaped body having a circumference, each pole piece further comprising a plurality of angularly-spaced pole fingers extending axially from the circumference of the body of the pole piece, each body of each pole piece further defining a plurality of radially-outwardly-opening recesses between adjacent pole fingers of the pole piece. The method comprises affixing permanent magnets into at least

some of the recesses.

In some embodiments, the present invention facilitates the use of generally-conventional Lundell machine technology, but with considerably increased power output per unit volume of the machine. In doing so, the present invention provides significant advantages over alternative designs.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of a rotor 10 for an electrical machine, the rotor 10 including permanent magnet inserts 34;

Figure 2 is an end view of rotor 10 of Figure 1;

Figure 3 is a side view of rotor 10 of Figure 1;

Figure 4 is a side view of a rotor 10' according to a second embodiment of the present invention, where bands 50 and 52 help retain permanent magnets 34; and

Figure 5 is an end view of rotor 10' of Figure 4.

Referring first to Figure 1, relevant portions of a rotor 10 for an electrical machine such as a motor vehicle alternator are illustrated. The rotor includes a first pole piece 12 and a second pole piece 14. Each pole piece includes a generally disc-shaped body 16. Each pole piece further comprises a plurality of pole fingers 18 which are angularly disposed about a circumference of their respective pole piece 12 or 14 and which extend axially from the body 16 of the pole piece.

Pole pieces 12 and 14 are mounted on a shaft 20 and along with shaft 20 define an axis of rotation of rotor 10. Rotor 10 further comprises a field coil 28 which itself comprises a bobbin 30 and wire 32. Field coil 28 is mounted within first pole piece 12 and second pole piece 14 for rotation therewith. Those skilled in the art will recognize rotor 10 as being generally of the "Lundell" or "claw pole" configuration.

Additionally shown mounted on pole piece 14 are a plurality of permanent magnets 34. Each permanent magnet 34 is mounted between two pole fingers 18 within the radially-outwardly-opening recess 36 between each pair of pole fingers 18. Although omitted in Figure 1 for clarity in showing the structure of pole piece 12, permanent magnets are also similarly provided between pole fingers 18 of pole piece 12.

Refer now additionally to Figures 2 and 3. Figure 2 is an end view of rotor 10 and Figure 3 is a side view of rotor 10. Assume that pole piece 14 is the pole piece whose pole fingers 18 are magnetised as north poles by energization of field coil 28. The permanent magnets 34 affixed to pole piece 14 are preferably magnetised such that their radially-outward portions have south magnetic polarity and their radially-inward portions have north magnetic polarity.

On the other hand, for permanent magnets 34 mounted to pole piece 12, those permanent magnets 34

will each have a radially-outward portion preferably having north polarity and a radially-inward portion preferably having south polarity. Pole fingers 18 of pole piece 12 will be magnetised as south poles by the energization of field coil 28. Note that in Figures 2 and 3, north and south magnetic poles are designated by "N" and "S", respectively.

It has been demonstrated that a rotor 10 including permanent magnets 34 as described in this embodiment of the present invention has a considerably higher power output than a conventional "Lundell" rotor of otherwise comparable physical size and design. It is believed that this performance is very largely due to the unique mounting locations of permanent magnets 34. The magnetic flux of permanent magnets 34 directly links with the stator (not shown) of the machine, without significantly going through the bodies of pole pieces 12 and 14. Thus, magnetic saturation of the bodies of pole pieces 12 and 14 due to the flux from field coil 28 does not appreciably degrade the ability of permanent magnets 34 to add to the flux linking the stator of the machine. Thus, the power output of the machine is increased without increasing the machine's physical size.

Permanent magnets 34 can be mounted to pole pieces 12 and 14 with, for example, adhesive.

Alternatively or additionally, permanent magnets 34 can be mounted to pole pieces 12 and 14 by one or more bands mounted about the circumference of rotor 10. This alternative is illustrated with reference to Figures 4 and 5. In the embodiment illustrated there, two bands 50 and 52 are placed about the circumference of rotor 10'. These bands 50 and 52 help retain permanent magnets 34, preventing radially-outward movement of permanent magnets 34.

Bands 50 and 52 are preferably non-magnetic and can be made of, for example, stainless steel, aluminium, or a composite material comprising carbon fibre (or similar material) and polymer resin. If bands 50 and 52 are made of metal, they can be first heated to cause them to circumferentially expand. Once they have expanded, they can be slipped onto rotor 10'. When bands 50 and 52 then cool, they will have a very secure fit to rotor 10'. If bands 50 and 52 are of a composite material, they can, for example, be wound directly onto rotor 10'.

Pole pieces 12 and 14 are preferably reduced in radius (by, for example, machining) in the two areas where bands 50 and 52 are affixed. This reduction in radius will allow the radially-outward surface of bands 50 and 52 to be flush with the radially-outward surfaces of pole fingers 18. Thus, the air gap between the radially-outward surfaces of pole fingers 18 and the stator of the electrical machine containing rotor 10' will not be increased by the addition of bands 50 and 52.

Further, bands 50 and 52 are preferably no thicker than needed to provide the strength to carry out their function described herein. Given that in the preferred design, portions of pole pieces 12 and 14 are reduced in radius where bands 50 and 52 are attached, this re-

duction in radius can tend to somewhat reduce the flux between rotor 10 and the stator (not shown) of the machine. That is, the air gap between rotor 10 and the stator is increased at the locations where bands 50 and 52 are attached. Minimising the thickness of bands 50 and 52 decreases the reduction in radius of pole pieces 12 and 14 where bands 50 and 52 are mounted.

## 10 Claims

1. A rotor for an electrical machine, said rotor comprising:

a first pole piece (12) and a second pole piece (14) together defining an axis of rotation of said rotor, each said pole piece comprising a generally disc-shaped body (16) having a circumference, each said pole piece further having a plurality of angularly-spaced pole fingers (18) extending axially from said circumference of said body of said pole piece; and  
a plurality of permanent magnets (34), each permanent magnet affixed to a body (16) of a said pole piece between two said pole fingers of said pole piece

2. A rotor for an electrical machine as claimed in Claim 1, wherein each said permanent magnet is affixed between exactly two said pole fingers of a said pole piece.

3. A rotor for an electrical machine as claimed in Claim 1, wherein:

each said body of each said pole piece defines a plurality of radially-outwardly-opening recesses between adjacent pole fingers of said pole piece and  
each said permanent magnet is located within one of said recesses

4. A rotor for an electrical machine as claimed in Claim 3, wherein each said permanent magnet has a radially-inward portion and a radially-outward portion, said radially-inward portion and said radially-outward portion having opposite magnetic polarities.

5. A rotor for an electrical machine as claimed in any one of the preceding Claims, wherein each said permanent magnet is affixed to a said body with adhesive or by one or more bands located about a circumference of said rotor

6. A rotor for an electrical machine as claimed in Claim 5, wherein said one or more bands are made of a non-magnetic material.



7. A rotor for an electrical machine as claimed in Claim 6, wherein said non-magnetic material is stainless steel is aluminium or is a composite comprising carbon fibre or polymer resin.

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8. A method for manufacturing a rotor for an electrical machine, said rotor comprising a first pole piece and a second pole piece together defining an axis of rotation of said rotor, each said pole piece comprising a generally disc-shaped body having a circumference, each said pole piece further comprising a plurality of angularly-spaced pole fingers extending axially from said circumference of said body of said pole piece, each said body of each said pole piece further defining a plurality of radially-outwardly-opening recesses between adjacent pole fingers of said pole piece, said method comprising:

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affixing permanent magnets into at least some of said recesses.

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9. A method as claimed in Claim 8, further comprising affixing one or more bands about a circumference of said rotor, said bands located to prevent radially-outward movement of said permanent magnets.

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10. A method as claimed in Claim 9, further comprising heating said one or more bands to cause circumferential expansion prior to affixing said bands about the circumference of said rotor.

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